Pest Management Grants Progress Report

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Determining Seed Bank Levels in Citrus Orchards:

A Basis for Designing A Weed Control Program

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Abstract

This research investigates seed bank levels in citrus orchards that differ in duration of herbicide use and differ in size of citrus tree canopy. Soil samples were taken from fields and seeds were extracted according to membership in classes of duration of use and classes of canopy size. Results indicate that total seeds in citrus decrease with increasing duration of herbicide application. Seed banks tended to be higher in the tree row than in the tree middle. Older orchards (> 27 years) that had longer duration of complete weed control had similar seed bank densities for tree rows and tree middles. Weed emergence and density were evaluated in the field from plots which received preemergent herbicide application and plots that did not receive preemergent herbicide application. Five species were the most common species detected: common groundse (*Senecio vulgaris*), horseweed (*Conyza canadensis*), prickly lettuce (*Lactuca serriola*), annual sowthistle (*Sonchus oleraceus*) and panicle willowweed (*Epilobium paniculata*). All five of these species have pappus bearing seeds that allow for wind dispersal and would continually be invading citrus orchards. Weed species were only found on the tree row in the newly planted trees where herbicides had been applied for less than 4 years.

EXECUTIVE SUMMARY

In citrus orchards, weeds are controlled primarily with preemergent herbicides during fall and winter months. Postemergent herbicide application follows and efficiently prevents a large number of species from replenishing their respective seed banks. Through time, seed banks should diminish but farmers can not evaluate seed bank depletion since the weeds are controlled prior to their emergence, preventing detection by the farmers. This project is to identify long-term seed bank dynamics using easily obtained information on duration of herbicide use and size of citrus tree canopy. The results from this study should allow farmers and private consultants to chose modifications to their weed management programs that balance risk of weed control failure with environmental or health risks. The specific objectives of this project were: 1) to determine weed species' seed density and percentage of viable seeds, and 2) to evaluate weed species emergence and density in the field for classes of duration of herbicide use and classes of size of citrus tree canopy by diameter. In object 1, soil samples were taken within each duration class from the middle of tree rows and along the tree row. Dried soil samples were washed using a hydroneumatic elutriator. Counts from the sieves were combined to determine the number of total seeds for each soil sample In object 2, Five tarps (size 12 x 10 ft) were put in each citrus field (total 23 citrus fields selected) before herbicide application to keep area free from herbicide treatment in November 1999. After application, tarps were removed. Weed emergence and density were evaluated by species in April 2000. The results showed total seeds in soil of citrus orchards decreased with increasing duration of herbicide application. Field evaluation of weed emergence showed weed species was only found on the tree row in newly planting citrus in Class I.

Introduction

The overall goal of this proposed research is to manage weeds in citrus orchards effectively and economically while maintaining environmental and human health. Achieving this goal is aided by a decision support tool that identifies long-term seed bank dynamics using easily obtained information on duration of herbicide use and size of citrus tree canopy. This approach should allow farmers and private consultants to chose modifications to their weed management programs that balance risk of weed control failure with environmental or health risks. Economically, this decision support tool should help farmers and private consultants reduce inputs making their enterprise more profitable. The specific objectives of this project were: 1) to determine weed species' seed density and percentage of viable seeds, and 2) to evaluate weed species emergence and density in the field for classes of duration of herbicide use and classes of size of citrus tree canopy by diameter.

It is widely recognized that seed dormancy and germination strategies contribute to the perpetuation of weeds as agricultural pests. Herbicide application can control weeds after germination but dormant seeds remain. Seed banks decline if mortality of germinating seed and dormant seed exceeds replenishment of the seed bank. Through time, these seed banks should diminish but farmers cannot evaluate seed bank depletion since the weeds are controlled prior to their emergence and hence detection by the farmer. Herbicides are applied in citrus orchards throughout the life of the orchard that usually exceeds 25 years. Weed management within an orchard possibly could change with orchard age if seed bank depletion in citrus orchards was understood. A better understanding of the risk of weed pressure in citrus should allow farmers to make changes to their weed control practices that reflect weed pressure.

The species composition and density of weed seed in soil vary greatly and are closely linked to management practices and environmental conditions of the cropping land and varies between fields and within fields. Citrus orchards are managed as a no-till system with no vegetative cover on the orchard floor. Continuous herbicide use should influence seed densities and species composition of the seed bank. Researchers have reported a steady decline in total seed bank densities in plots receiving continuous herbicide applications (Burnside et al., 1986; Schweizer and Zimdahl 1884). The seed bank was reduced 98% after atrazine was applied to corn fields for 6 years (Schweizer and Zimdahl, 1984). When triazines were applied consecutively to corn fields for 16 yr in England, the seed bank decreased 96% and number of species was reduced by half (Roberts and Neilson, 1981). Sub-lethal doses of herbicide reduced seed production of several weed species as much as 90 % (Biniak and Aldrich, 1986; Salzman et al., 1988).

Tree size affects the amount of light reaching the soil surface. Reduced light to the soil surface reduces germination and growth of weeds.

Although seed banks have been studied extensively, seed banks have not been investigated in citrus orchards. Knowledge gained through this research will provide the foundation for development of new strategies and more efficient techniques, resulting in more economical weed management systems that reduce the risk of damage to the environment.

Material and Methods

Objective 1: To determine seed density and percentage of viable seeds under different duration of herbicide use and size of citrus tree canopy.

Site Selection: Orchard sites for soil sampling were selected by first considering duration of herbicide use. Seven duration classes were selected at < 4 yr, 4 - 8 yr, 9 - 13 yr, 14 - 18 yr, 19

- 23 yr, 24 - 27 yr, and > 27 yr of clean floor management. Within each duration-class, we measured canopy size. In the San Joaquin Valley, citrus commonly is planted with 6.7 m row spacing and 6.1 m tree spacing.

Soil Sampling: Soil samples were taken within each duration class. Soil samples were taken using a W-shaped pattern imposed over the orchard with nine soil samples taken in the middles between tree rows and 9 samples taken on the tree rows. Each of the samples was a composite of either five subsamples taken from the middle of tree rows and three subsamples taken along the tree row (Fig. 1). All samples were taken to a depth of 5 cm with an auger. The soil samples were air-dried.

Seedbank Determination: Samples were air-dried. Dried soil samples were washed using a hydroneumatic elutriator. Soil samples were placed in the elutriation chamber and washed for 15 - 20 minutes (dependent on clay content) . Four sieves with mesh size of 2 mm, 500 μm, 250 μm, and 120 μm were used to collect seeds and other contents. After washing, sieves were removed and the collected contents dried. The sediment at the bottom of the elutriation chamber was washed into a 355 μm sieve of and dried. Each sieve was examined under a dissecting microscope. Counts from the sieves were combined to determine the number of total seeds for each soil sample.

Seeds from each sample have been stored, awaiting identification. Seeds will then be watered and incubated on a 25 C/ 15 C diurnal cycle to determine percent germination. Seeds that do not germinate will be subjected to either tetrazolium analysis (TZ) or a gentle squeeze test if TZ is not possible.

Objective 2. To evaluate weed emergence and density in the field under different duration of herbicide use and size of citrus tree canopy.

Five tarps (size 12 x 10 ft) were put in each citrus field (total 23 citrus fields selected) before herbicide application to keep area free from herbicide treatment in November 1999. After application, tarps were removed. Weed emergence and density were evaluated by species in April 2000.

Results

Objective 1

A total of 29 sites have been sampled (Table 1).Greater seed densities were counted in the tree row than were counted in the tree middle (Table 2). When citrus orchards had over 27 years of clean floor management, seed densities were similar for tree rows and tree middles (Table 2). The relation between tree diameter and tree classes is presented in Figure 2. The diameter increases as the citrus ages. The number of seed along the tree row and in the middle of tree rows are presented in Figure 3 & 4.

Object 2

To effectively manage vegetation, we must know the weed species present, their abundance and location in the orchard. The weed density should reflect seed bank densities that in turn, are affected by floor management activities. Weed species that have wind-borne seed may continually invade orchards and may not by found at high densities in the soil seed bank. Five weed species emerged from 29 sites and include common *groundsel (Senecio vulgare*), horseweed (*Conyza canadensis*), prickly lettuce (*Lactuca serriola*), annual sowthistle (*Sonchus oleracea*) and panicle willowweed (*Epilobium paniculatum*)groundsel (Table 3). These weeds are present in the middles between tree rows. Weed species were only found on the tree row in the newly planted trees in Class I. On the tree row, tree sizes affect light reaching the soil surface. Reduced light at the soil surface reduces germination and growth of weeds. Among the five species, common groundsel is the mostly present. The density was as high as 39 per 120 ft^2 even in the oldest citrus orchards. Common groundsel is reported to have plant populations resistant to simazine in California Horseweed and prickly lettuce are two species found in younger citrus without preemergence herbicide application. These data could help consultants and farmers modify weed management to reduce cost of weed control by changing application rates, skipping applications or relying on postemergent strategies for a larger part of the season. Field evaluation of bioeconomic models has already shown their potential to reduce herbicide use while maintaining weed control and increasing economic return. Model recommendations reduced weed control costs and resulted in an average annual herbicide application of 1.1 kg ai ha^{-1} compared to 3.5 kg ha^{-1} with a standard treatment (Forcella et al., 1996). Field emergence patterns of weeds could be used for timing of postemergent application of herbicide (Ogg and Dawson, 1984). Another field evaluation conducted by Buhler et al.(1996) showed that herbicide use decreased 27% using seed bank data and 68% using seedling data compared with a standard herbicide treatment.

Discussion

The newly planted citrus in Class I showed that only few seeds were found. This field was replanted from a previous citrus orchard. Crop rotation history as well as herbicide application history are important factors for decision-making for reduced cost and reduced environmental risk weed management.

The relationship of seed bank to emergence is an active field of research but one that we are not able to go into in any depth other than what we have proposed which is to leave 5 locations at each orchard unsprayed and to count emerged plants. We can compare these emergence counts to the seed bank data we have taken. Our sites will have been without herbicide application for approximately one year prior to counts being made of emergence from the 5 locations in each orchard. Hopefully most herbicide effects will have dissipated, unless bromacil was used. Our herbicide dissipation work with simazine suggests that we should have little residual effects. Most herbicide labels for diuron also show many susceptible rotational crops can be planted after one year. We evaluated weed species and density in the filed and will do it again in winter 2000.

Summary and Conclusions

Total seeds in soil of citrus orchards decreased with increasing duration of herbicide application. Field evaluation of weed emergence showed weed species was only found on the tree row in newly planting citrus in Class I. A combination of continuous use of herbicides and shading may contribute overall to lower seed banks and weed populations as orchards age. Results from this study will help consultants and farmers modify weed management to reduce cost of weed control by changing application rates, skipping applications or relying on postemergent strategies for part of the season.

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Appendices

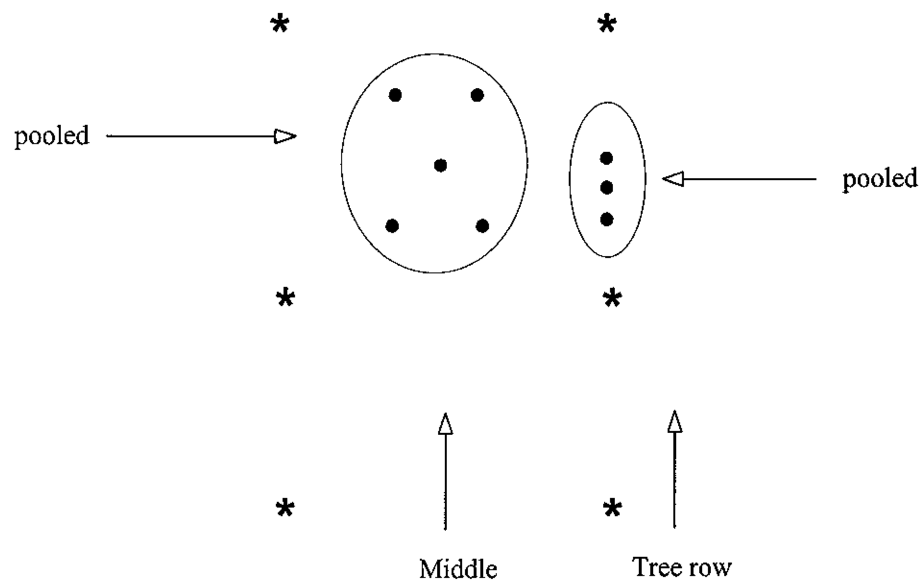

Figure 1. A diagram of soil sampling for objective

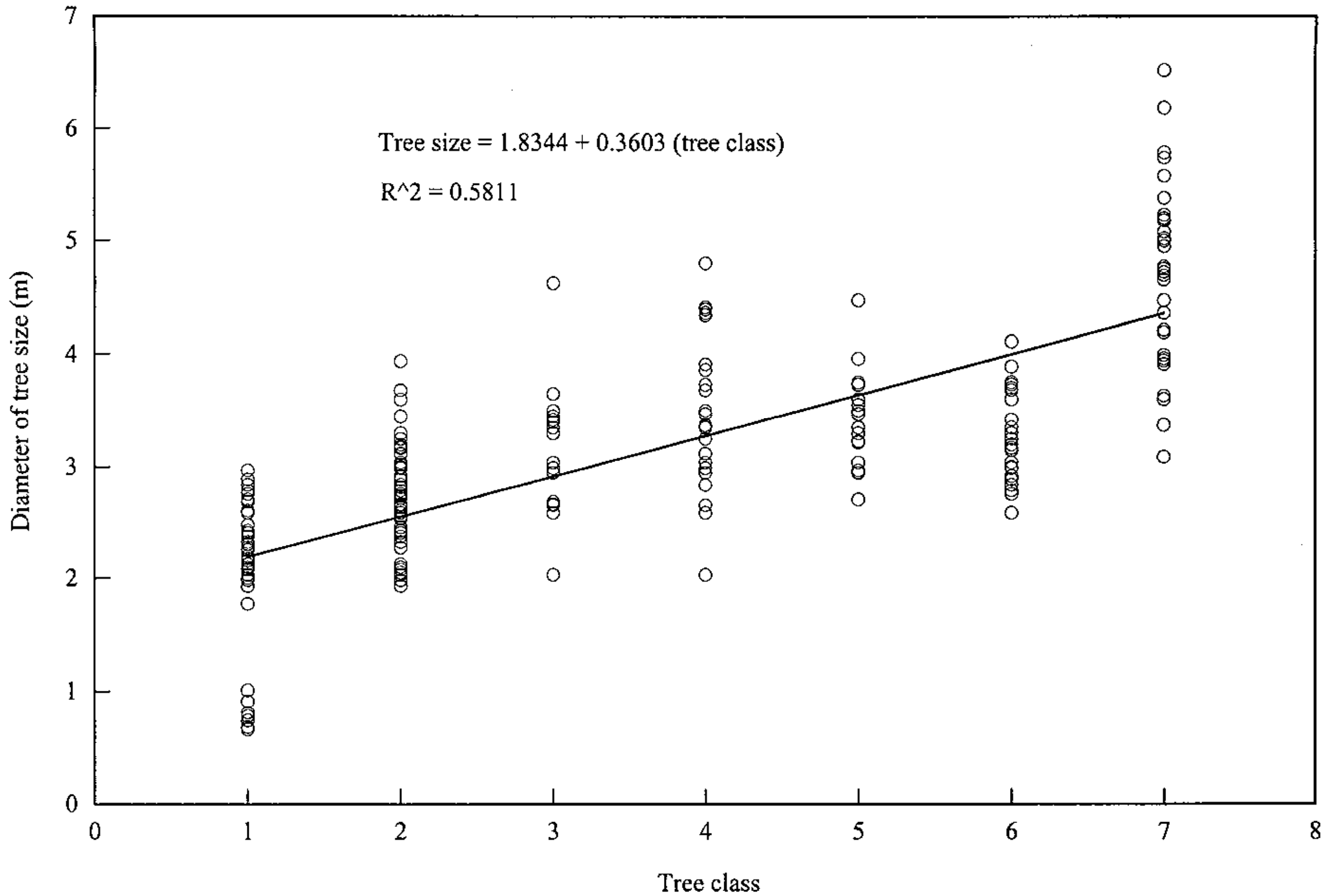

Figure 2: The relation between tree size and tree classes. (In X axis title: 1 = Class I, 2 = Class II…7 = Class VII)

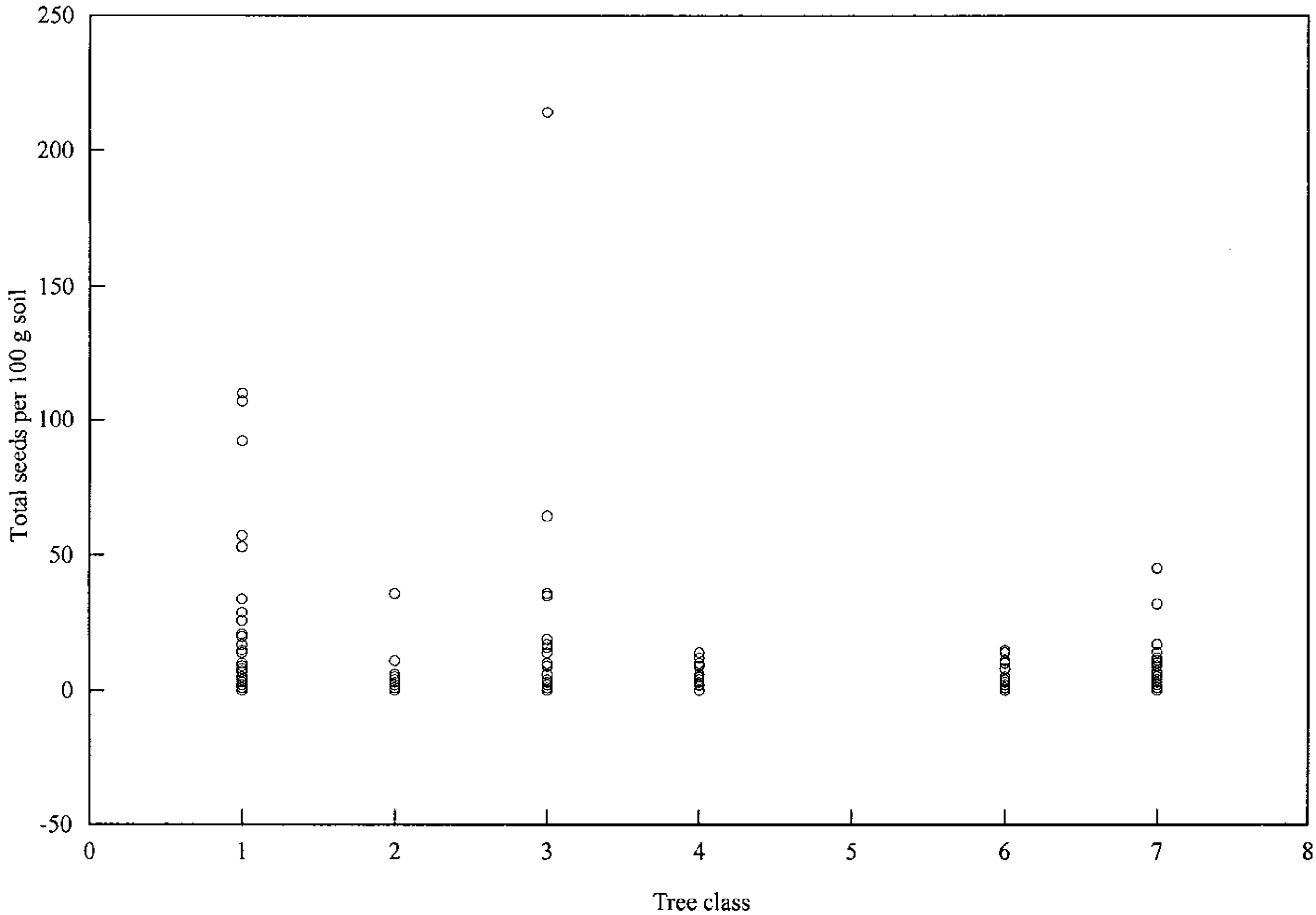

Figure 3. The number of seeds along the tree row with tree classes. (In X axis title: 1 = Class I, 2 = Class II … 7 = Class VII)

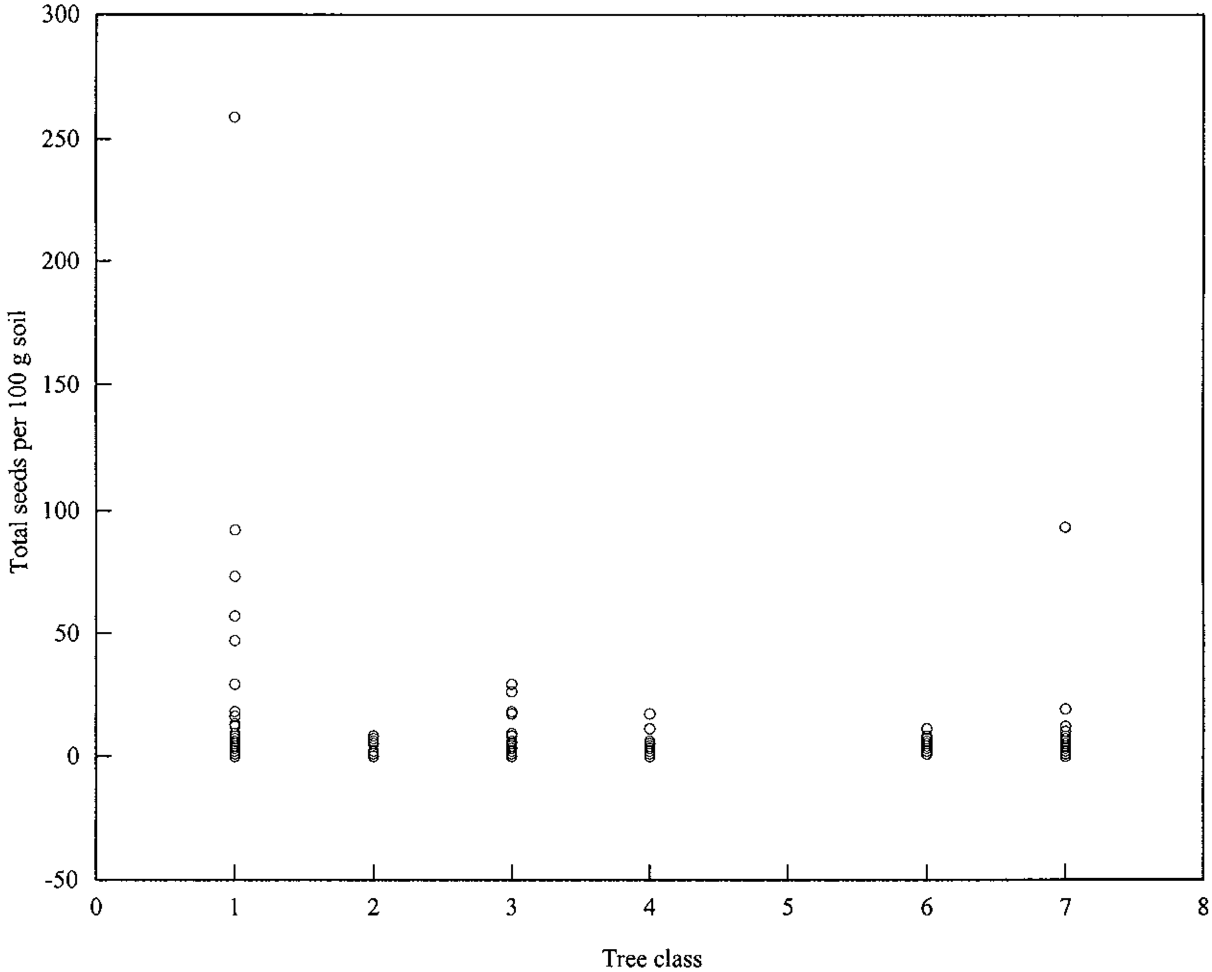

Figure 4. The number of seeds in the middle of tree rows with tree classes. (In X axis title: 1 = Class I, 2 = Class II … 7 = Class VII)

Table 1. Citrus sites sampled for seed bank determination for each class.

Class	Age (year)	Number of Sites	Sites to be processed
Class I	< 4	6	
Class II	4 – 8	8	
Class III	9 – 13	2	
Class IV	14 – 18	3	
Class V	19 – 23	3	
Class VI	23 – 27	3	
Class VII	> 27	4	

Table 2. The relation between total seeds and class of herbicide use

Class of herbicide use	Age (year)	Tree diameter (m)	Citrus sites sampled	Tree row (# / 100 g soil)	Middle of tree row (# / 100 g soil)
Class I	< 4	< 1.0	2	3.0	3.1
		< 2.7	4	19.7	21.8
Class II	4 – 8	2.3 – 2.7	3	4.6	1.7
Class III	9 – 13	2.8 – 3.5	2	16.7	6.1
Class IV	14 – 18	4.0 – 4.2	2	5.1	2.8
Class V	19 - 22	3.6 – 3.7			
Class VI	23 – 27	3.3– 3.5	2	5.4	4.7
Class VII	> 27	4.0 – 5.2	4	6.1	6.0

Table 3. Emergence of weeds across duration of herbicide use classes (# / 12 x 10 ft).

Citrus class	Treatment	Common. Groundsel	Horse Weed	Prickly Lettuce	Willow Weed	Annual Sowthistle
I	Control	5.0	10.2	1.4	1.0	0.1
	Applied	3.0	2.0	0.7	0.2	0.0
II	Control	2.0	5.8	5.2	1.6	1.0
	Applied	1.7	0.5	0.0	0.0	0.0
III	Control	39.8	0.0	0.0	0.0	0.0
	Applied	29.2	0.0	0.0	0.0	0.0
IV	Control	0.7	1.0	0.0	0.1	0.0
	Applied	0.1	0.0	0.0	0.0	0.0
V	Control	1.3	1.5	1.9	0.1	0.4
	Applied	1.1	0.2	0.1	0.0	0.0
VI	Control	0.5	0.8	1.9	0.0	0.4
	Applied	0.3	0.1	0.1	0.0	0.3
VII	Control	39.0	0.8	0.6	0.2	0.0
	Applied	22.0	0.2	0.1	0.0	0.0